

WEATHER ABNORMALITIES IN THE UNITED STATES (SEVENTH NOTE): TREND OF PRECIPITATION

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A study of prolonged drought in southeast Virginia and the adjacent area in northeastern North Carolina has developed the fact that a number of years since 1900 and even before that date were years of generally deficient precipitation in those regions. This suggested an inquiry into the rainfall distribution in the United States since the beginning of the Federal weather service in 1871. At that time the number of stations reporting rainfall was but 48, but by the use of stations in the network reporting to the Smithsonian Institution and by supplementing these by Federal stations established during the early seventies, 1871-76, the total number of stations having at least 50 consecutive years of rainfall records was increased to 123. (See Table 1.)

TABLE 1.—Precipitation in United States 1871-1895 and 1896-1920 compared

State and station	Difference	State and station	Difference
	<i>Inches</i>		<i>Inches</i>
Alabama:		Mississippi: Vicksburg.....	-6.6
Mobile.....	-0.1	Missouri:	
Montgomery.....	+0.2	Oregon ¹	+2.0
Union Springs ¹	+10.4	Saint Louis.....	-0.2
Arizona:		Springfield.....	-1.8
Tucson.....	-1.4	Nebraska:	
Yuma.....	+0.3	North Platte.....	+1.3
California:		Omaha.....	-5.1
Chico ¹	+2.9	New England S.:	
Folsom ¹	+0.6	Amherst, Mass. ¹	-0.4
Georgetown ¹	-1.0	Boston, Mass. ¹	-7.1
Marysville ¹	+3.0	Canton, Conn. ¹	+1.5
Nevada City ¹	-3.8	Concord, N. H. ¹	-1.4
Sacramento.....	-3.3	Cornish, Me. ¹	+1.4
San Bernardino ¹	-1.2	Fitchburg, Mass. ¹	+0.6
San Diego.....	-0.9	Hartford, Conn. ¹	+1.4
San Francisco.....	-3.0	Lakeport, N. H. ¹	-1.4
Santa Barbara ¹	+1.9	Lake Cochituate, Mass. ¹	-1.9
Summit ¹	+2.6	Lowell, Mass. ¹	-4.1
Colorado: Denver.....	-0.1	New Bedford, Mass. ¹	-2.3
District of Columbia: Wash- ington.....	-2.5	New Haven, Conn. ¹	-3.5
Florida:		New London, Conn. ¹	-3.8
Key West.....	-0.4	Orono, Me. ¹	-3.6
Jacksonville.....	-9.6	Portland, Me. ¹	-0.6
Georgia:		Providence, R. I. ¹	-5.4
Atlanta.....	-3.2	Waltham, Mass. ¹	-0.1
Augusta.....	-4.2	New Jersey:	
Rome ¹	+6.6	Atlantic City.....	-0.3
Savannah.....	-6.4	Moorestown ¹	+1.7
Idaho: Boise.....	-0.4	Newark ¹	+1.9
Illinois:		New Brunswick ¹	-0.2
Chicago.....	-4.3	Nevada: Winnemucca.....	-0.2
Calro.....	-3.4	New Mexico: Santa Fe.....	-0.1
Marengo ¹	-1.3	New York:	
Peoria ¹	+0.3	Albany.....	-6.1
Indiana:		Buffalo.....	-5.0
Indianapolis.....	-1.4	Cooperstown ¹	+6.6
Veray ¹	+0.7	New York City.....	-3.4
Iowa:		Oswego.....	-0.5
Davenport.....	-4.2	North Carolina:	
Dubuque.....	-4.7	Hatteras.....	-19.6
Independence ¹	-1.6	Manteo.....	-5.6
Keokuk.....	-3.9	Weldon ¹	-0.6
Logan ¹	-4.2	Wilmington.....	-11.1
Muscatine ¹	-2.5	North Dakota: Bismarck.....	-1.3
Kansas:		Ohio:	
Dodge.....	-1.3	Cleveland.....	-3.2
Hays ¹	+1.5	Cincinnati.....	-3.4
Independence ¹	+0.0	Marietta ¹	+2.1
Lawrence ¹	+0.6	North Lewisburg ¹	+1.0
Manhattan ¹	+2.4	Portsmouth ¹	+1.2
Kentucky: Louisville.....	-4.4	Wauseon ¹	+1.5
Louisiana:		Oregon:	
New Orleans.....	-3.8	Astoria ¹	+1.8
Shreveport.....	-8.0	Portland.....	-6.6
Maryland: Baltimore.....	-2.5	Pennsylvania:	
Michigan:		Pittsburgh.....	-0.8
Alpena.....	-6.1	Philadelphia.....	+2.7
Detroit.....	-0.5	South Carolina:	
Grand Haven.....	-2.7	Camden.....	+3.5
Lansing.....	+0.7	Charleston.....	-16.5
Marquette.....	+0.3	Pinopolis ¹	-1.7
Minnesota:		Tennessee:	
Duluth.....	-4.2	Knoxville.....	-4.3
Minneapolis.....	+1.1	Memphis.....	-7.4
Saint Paul.....	+1.4	Nashville.....	-3.9

¹ Cooperative station.

TABLE 1.—Precipitation in United States 1871-1895 and 1896-1920 compared—Continued

State and station	Difference	State and station	Difference
	<i>Inches</i>		<i>Inches</i>
Texas:		Virginia—Continued.	
Austin.....	-1.1	Lynchburg.....	-2.9
Galveston.....	-4.6	Norfolk.....	-12.3
Palestine.....	-9.6	Wisconsin:	
Utah:		La Crosse.....	+1.0
Corinne ¹	+1.8	Madison ¹	-4.5
Ogden ¹	+2.6	Manitowoc ¹	-4.7
Salt Lake City.....	+0.3	Milwaukee.....	-2.3
Virginia:		Wyoming: Cheyenne.....	+3.3
Cape Henry.....	-11.1		

¹ Cooperative station.

The basic period of years was 1871-1920 but the use of records for places that began during the years 1871-1876 necessitated of course the extension of the series to years after 1920. Rainfall distribution over large areas for short periods of time is notoriously irregular or spotted. While these irregularities are more or less smoothed out in 50 years in an area so large as continental United States, yet it was found that in certain areas there seems to have been a real diminution of the precipitation. The method followed in the study was to arbitrarily divide the 50-year period into two halves, the first including the years 1871-1895 and the second 1896-1920. The difference between the 25-year averages for the two periods served to show whether precipitation had increased or diminished during the 50-year period.

The differences between the means of the two periods, assuming that the exposure of the rain gages had been practically the same throughout the period should not be widely separated unless there has been a real increase or diminution in the precipitation for the regions occupied by the respective stations.

Probably less than 5 per cent of the records used were derived from gages that presumably had the same exposure from beginning to end. The labor of determining the successive exposures of rain gages during the last fifty-odd years and of analyzing the records of rainfall for each exposure is prohibitive. Owing to causes over which the Weather Bureau has no control it has been necessary during the last half century to make frequent changes in office-quarters occupied by the field stations; almost invariably the change has been from a low to a higher building and with each increase in elevation the probability of a faulty gage exposure has increased.

Stations west of the 100th meridian are too few in number to afford any reliable indication as to changes, if any that have taken place in that region. The group of stations in middle California give contrary results possibly due to local differences that the run of years has not completely eliminated. An area extending from south-east Wyoming through Nebraska and part of Kansas to northwest Missouri appears to have had slightly greater rainfall in the second than in the first half of the period and this is also true of a part of northeast Utah in the vicinity of Great Salt Lake, also of southeast Minnesota; Ohio, also has a record of slightly greater rainfall the second than in the first half of the 50-year period.

Considering now the areas where the precipitation of the second half of the period was less than that of the first,

there are two outstanding areas where the difference in rainfall is pronounced, viz, from northeast Texas through Louisiana and Mississippi to western Tennessee and the lower Ohio Valley and again along the Atlantic Coast from the Virginia Capes to Jacksonville, Fla., not to mention the upper Lake region from Alpena to Milwaukee.

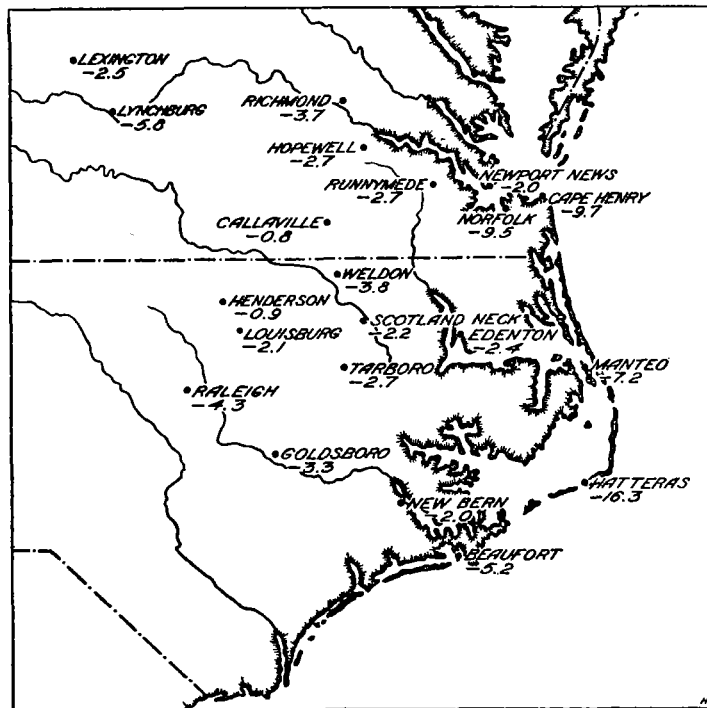


FIGURE 1.—Average annual deficiency of precipitation in southeast Virginia and northeast North Carolina for the 11 years 1909-1911

Detailed examination of the rainfall records maintained at Cape Henry and Norfolk, Va., and Hatteras, N. C., has shown conclusively, that the rainfall catch at those stations for a part of the second half has been deficient due in the main to gage exposure. At the same time it was also established that precipitation, rather generally east of the Appalachians in Virginia and the Carolinas has been less than normal for a number of years subsequent to 1900.

A special study has been made of the region shown in Figure 1 for the years 1909 to 1919 both inclusive. I give in Table 2 the annual departure of the rainfall from the normal for 22 stations in the area in question; two of the years, viz, 1910 and 1917, might easily be classed as years of normal or slightly above normal rainfall and curiously both of these years were dry years in the United States as a whole.

A correction has been determined and applied to the record of rainfall for Cape Henry and steps have been taken to determine a proper correction for the Norfolk and Hatteras records. The announcement of these corrections will have to be deferred until such time as comparative rain-gage readings extending over a year or more are available.

Heavy rains in the region shown in Figure 1 are due almost wholly to the northeastern movement of cyclonic storms from the Gulf of Mexico or thereabouts to New England, including those tropical cyclones which move northward along the coast or a short distance therefrom. An important consideration, at all times, is the rapidity of movement of the storms in question since whenever the movement is retarded, for example, by high pressure over New England, the additional time that the cyclone center rests over any part of the area gives that area more continuous and naturally a greater quantity of rainfall. It will happen therefore that the seemingly fortuitous pressure distribution may be the cause of greater than normal rainfall.

Aside from a deficient catch due to improper exposure of the rain gage there are times when the natural rainfall over the region in question is considerably less than the normal. The weather maps on such an occasion show that the Appalachians evidently cast a rain shadow over the piedmont region to the eastward; this rain shadow is apparent when cyclonic storms moving to the eastward along the Canadian border pass down the St. Lawrence valley without giving appreciable rain south of the Pennsylvania line. There is another cause that operates to diminish the rainfall of the Carolinas and Virginia, viz, the westward extension of high pressure from the Atlantic, as when the Bermuda anticyclone is well developed to the westward and the high pressure, 30.10 to 30.20 inches, overlies the Carolinas and Georgia. At such time the rainfall is light and irregularly distributed.

TABLE 2.—Annual precipitation departures 1909-19

[Inches and tenths]

Stations	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	Average	Normal annual
Lynchburg, Va.	-10.5	-1.4	-2.6	-0.8	-5.5	-10.0	-7.8	-2.1	-9.3	-10.2	-3.1	-5.8	41.7
Callaville, Va.	+0.1	+7.6	-1.3	-8.4	-5.7	-3.6	-6.5	-5.0	+5.2	+5.4	+3.0	-0.8	45.5
Richmond, Va.	-7.6	+1.3	-4.8	-6.2	-4.1	-9.0	-5.4	-4.6	+1.5	-0.5	-1.7	-3.7	41.8
Hopewell, Va.	-3.5	+7.4	-7.4	-8.2	-6.7	-4.6	-6.5	-2.5	-2.8	+6.5	-0.5	-2.7	44.8
Williamsburg, Va.	-2.0	+3.0	-3.1	-5.6	-3.2	-17.3	-6.5	-2.5	+4.3	+6.0	-4.0	-2.8	46.4
Runnymede, Va.	-2.9	+1.3	-5.3	-8.0	+1.5	-5.6	-7.0	-10.0	+6.5	+6.5	-6.9	-2.7	49.2
Newport News, Va.	-1.8	+4.7	-2.9	-10.7	-0.2	-7.0	-0.9	-6.3	+3.7	+3.6	-4.4	-2.0	45.3
Diamond Spgs., Va.	-5.5	-1.3	-2.1	-4.4	+4.2	-5.0	-2.5	-1.1	+8.1	-2.9	-2.8	-1.4	42.6
Norfolk, Va.	-12.6	-6.1	-7.5	-12.0	-3.0	-11.4	-10.3	-12.6	-0.8	-15.5	-13.0	-9.5	46.4
Cape Henry, Va.	-10.4	-6.7	-11.6	-12.3	-1.3	-12.3	-19.2	-12.3	+0.1	-10.8	-12.4	-9.9	46.9
Henderson, N. C.	-7.8	+1.9	+5.1	-1.1	+0.3	-1.3	-6.1	-5.6	+4.3	+0.8	+2.9	-0.9	44.8
Weldon, N. C.	-10.5	+3.7	-7.3	-8.3	-7.0	-7.3	-9.3	-4.8	+6.0	-1.4	+4.0	-3.8	46.1
Louisburg, N. C.	-5.3	+4.7	-1.4	-8.0	+1.9	-1.9	-10.6	-5.2	+5.1	-3.4	+1.3	-2.1	45.7
Raleigh, N. C.	-6.8	+0.5	-8.6	-7.1	+0.5	-2.5	-7.1	-5.7	+2.0	-4.9	-5.9	-4.3	46.6
Tarboro, N. C.	-3.2	-0.6	-8.5	-4.5	+0.0	-5.9	-4.1	-4.3	-4.0	-8.8	-2.7	-3.5	49.6
Goldsboro, N. C.	-9.3	+3.1	-15.8	-5.1	+2.9	-1.7	-2.1	-8.0	+6.8	-5.8	-1.7	-3.3	50.6
Edenton, N. C.	-3.5	+5.3	-9.1	-8.3	+2.4	-0.8	-14.9	-10.8	+11.1	+4.9	-3.2	-2.4	50.4
Scotland Neck, N. C.	-1.0	-0.3	-2.7	-2.1	-0.3	-4.0	-3.7	-0.4	+2.0	-9.1	-2.1	-2.2	42.1
Manteo, N. C.	-2.6	+4.7	-16.2	-6.5	-8.5	-16.2	-8.2	-11.6	-3.9	-11.2	-5.2	-7.2	52.5
Hatteras, N. C.	-19.3	-19.6	-25.1	-5.0	-11.3	-17.1	-16.1	-16.6	-9.8	-17.7	-21.5	-16.3	54.7
Beaufort, N. C.	-6.7	-6.7	-15.7	+7.7	+1.8	-3.0	-9.8	-5.7	+1.5	-11.4	-9.1	-5.2	48.5
Newbern, N. C.	-5.0	+12.6	-18.8	-0.3	+4.6	+3.6	-10.3	-6.8	+4.3	±0.0	-10.0	-2.0	56.5